Five things you can learn from leaf tissue analysis

Lab results are incredibly useful in hydroponics, as they give us a quantitative view of what's going on within our crops. From the potential array of analysis that can be carried out, few give us as much information as leaf tissue analysis. Despite this fact, few growers ever routinely carry out this analysis, as it's often perceived as unnecessary unless problems are showing up within a crop. In this article I want to talk about five different pieces of information that leaf tissue analysis can give us that can be very useful to hydroponic growers, not only when problems are showing up within the plants but as a routine measurement carried out at several different points within a plant's growing cycle.

Are the plants facing bad vapor pressure deficit (VPD) conditions. Leaf tissue analysis can tell you whether environmental conditions are pushing the plants in the wrong direction by showing you how the ratios of elements like Ca/Mg and Ca/K are skewed. Whenever a flowering plant is grown under a hydroponic solution with a Ca/N close to 1 and the VPD of the environment is very high, the amount of Ca will tend to increase a lot relative to K. This is mainly because the transport of Ca ions is controlled in a bigger proportion by the vapor pressure deficit of the environment, so plants grown at high VPD values will tend to show high Ca in tissue. See this paper, where it is clearly shown how VPD is directly proportional to Ca in tissue. At lower Ca concentrations, the difference tends to be greater between high/low VPD values.

Calcium content (mmol kg⁻¹ dry matter) of leaf margin (m) and centre (c) at two calcium levels and two vapour pressure deficits

calcium		vpd (kPa) 0.75 (l/l)	0.43 (h/h)	mean
16%	m	367	277	322
	c	429	390	410
64%	m	783	689	736
	c	941	920	931
mean	m	575	483	529
	c	685	655	670

VPD strongly affects Ca in tissue. Results in cucumber at two different VPD and Ca concentration levels.

Is there any heavy metal contamination going on. Growing plants for human consumption that contain a significant amount of heavy metals is usually unacceptable. This means that the early detection of heavy metal accumulation is important. Leaf tissue analysis can offer some early insights into heavy metal accumulation within leaves, in order to protect growers from getting end-products that contain large amounts of heavy metals. A plant that contains a significant amount of heavy metals in leaves before the flowering stage is not completely lost, given that heavy metals can be significantly hard to move within plant tissue. If this is detected the problem can be dealt with and inputs can be analyzed to figure out where the heavy metals are coming from. Waiting for the end-product to get a heavy metal test can be a significant waste of valuable time.

Are things where they are supposed to be. One of the reasons why it’s important to carry out leaf tissue analysis routinely is that they can provide you with an idea of whether things are where they are supposed to be or not. Comparing leaf tissue analysis from a plant this crop cycle with plants from past crop cycles can give you an idea about whether things are progressing as planned or whether there are significant deviations from the past. This might be particularly important if changes are being tested or implemented and can provide an early warning about plant stress or issues that have to do with nutrient or environmental inputs.

How nutrients are changing as a function of time. When a plant shows clear visual symptoms of a nutrient deficiency, the problem is already well underway and damage to the crop's yields have already happened. In order to stay on top of things and make sure the plants are not experiencing any problems, leaf tissue analysis can help us assert whether plants are able to transport all ions adequately. Drops in elemental levels as a function of time in tissue can signal that a problem is imminently going to happen unless the situation is evaluated and measures are taken. Weekly leaf tissue analysis of a crop is a very powerful tool to track nutrient uptake and potential issues, especially if all the data is properly logged and comparisons can be easily drawn. The change in the amount of total solids within leaf tissue can also be tracked and can be used as a way to gauge whether a plant is being exposed to excessively dry conditions.

Are your silicon supplements doing their job. Silicon is very hard to transport by most plants – especially plants like tomatoes and other commercially grown flowering plants – so ensuring that the silicon you provide your plants is reaching tissue becomes important. Potassium silicate applications can often be useless if the are not being done correctly, as the life of silicate in solution is very short once the pH is reduced to the level generally used in hydroponics (5.8-6.2). At this point silicate turns into silicic acid, which readily polymerizes to form insoluble silica chains. Doing leaf tissue analysis looking for silicon generally reveals if the applications of this element are being successful and how successful the assimilation is through the entire crop cycle.

The above are some of the ways in which leaf tissue analysis can help you improve your crop results, although they are by no means the only uses for these quantitative results. In general, leaf tissue analysis should be treated like very valuable information and judicious records of all nutritional and environmental conditions should be kept in association

with them. A consistent history of leaf tissue analysis is extremely valuable in a growing facility, it helps avoid problems, carry out effective changes and quantify the real results of experimental interventions.

A few basics of leaf tissue analysis in hydroponic crops

Adequate nutritional control is difficult. Although there are several tools to control your plant's chemical environment – such as pH, EC and ORP – in the end the main interest we have is to control the composition of plant tissue and how this composition affects plant development and yields. One of our sharpest tools to achieve this is leaf tissue analysis which allows us to look at plant composition levels and figure out if anything is wrong with our plants. Today I want to talk about this powerful tool, why it is not so simple to use, how to use it and why it can be so important in helping you figure out what's wrong with your crops.

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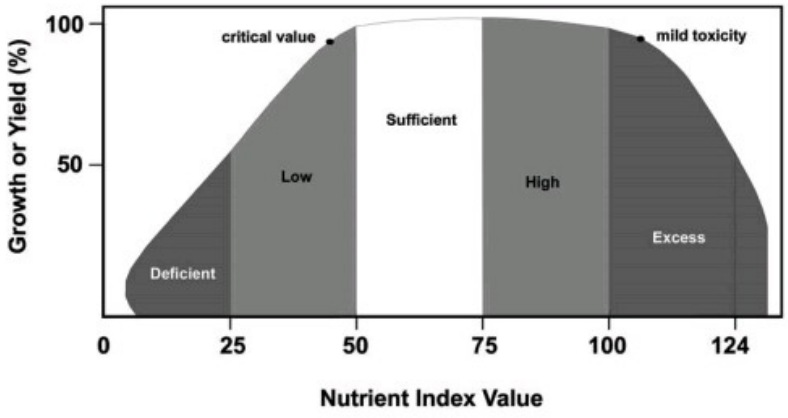

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The general model for nutrients and crop yields explains that plants will absorb nutrients till a point of maximum yield. After this point increasing nutrients will not increase or decrease yields substantially for a while but after a given point toxicity will prevail and plant yields will decrease due to nutrient toxicities and potentially osmotic pressure issues. This model is simplistic as it leads to an overall linear understanding of plant nutrients which is why growers often find leaf tissue analysis puzzling and confusing.

In leaf tissue analysis we most commonly obtain a sample from the plant's most recent mature leaves. This tissue is analyzed by a lab and we obtain a chart where the percentage composition of the plant tissue for the different elements is given. We can then look at reference values for healthy plants and if any of our nutrients are outside this range then there is certainly something wrong with our crop's nutrition. Sometimes the lab will also give you some reference values but bear in mind that this aren't necessarily healthy plants but the average of what the lab gets for the plant specie you are growing. You either want an academic/government reference for healthy sufficiency ranges or you want to grow healthy plants yourself and take a reference sample to use for your future crops.

The tricky part is to interpret the tissue analysis. For example let's suppose that your tissue analysis comes up with low phosphorous. The immediate intuitive response that we get from the general model of nutrient sufficiency is that we should increase P in solution to get the P up within the leaves. However nutrient relationships are non-linear and in many cases what you have isn't a general lack of enough nutrient in solution but a problem getting that nutrient up to the leaves. In the case of P for example it might range from having excess chloride to having a nutrient solution that is too cold. I haven't seen a single case in hydroponics where

low P in leaf tissue has actually been due to low P in the nutrient solution.

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Most Recent Mature Leaf — All Growth Stages

Macronutrients					
N	P	K	Ca	Mg	S
3.5–5.0%	0.30–0.65%	3.5–4.5 %	1.0–3.0%	0.35–1.0%	0.2–1.0%

Micronutrients					
Fe	Mn	Zn	Cu	B	Mo
50–300 ppm	25–200 ppm	18–80 ppm	5–35 ppm	30–75 ppm	0.1–1.0 ppm

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It is important then to realize that a problem within leaves is not necessarily a problem with concentration for that specific nutrient being too low or high in solution – in my experience it rarely is – but more so a problem with the balance of nutrients in solution or the environment that is causing a nutrient absorption issue. There are all sorts of antagonic and synergistic relationships between the different nutrients and the environment that will make this hard to interpret in many cases. To know what might be the cause first you will want to address all environmental issues that are known to cause toxicities/deficiencies and then look into addressing nutrient issues relative to the solution. You will want to pay a lot of attention to ratios instead of absolute concentrations.

You can have a perfectly good nutrient solution and the absorption problem might be related with something like transplant stress, root pathogens, incorrect carbon dioxide supplementation, light issues, temperature/humidity problems, etc. Growers tend to focus on the nutrient solution as the potential source and cure to all plant problems but the key is often in the environment and crop management more than within the actual nutrient solution. Even when the cause is the nutrient solution growers often misdiagnose the problem and

increase or decrease nutrient concentrations, more often than not making the problem worse.

Due to the above it is not surprising that few hydroponic growers find tissue analysis very useful. While in soil crops tissue analysis is usually used to manage fertilization and soil amendments in hydroponics the environment and solution are so controlled that the problems become much more difficult to diagnose and the solutions are often not what you would consider intuitive. It certainly requires a lot of reading and experience to properly interpret leaf tissue analysis and tackle the causal factors that are causing issues in hydroponic crops. However with enough experience or guidance leaf tissue analysis can be a great tool to know what your plant is taking, what it’s not and how these issues can be fixed.